**Cold air**

The lid on this can is airtight.

Air is trapped in the can.

The balls represent particles that the air is made of.

The air in the can is at room temperature.



The temperature of air in the can is lowered by putting it into a freezer.

These statements are about the air after it has cooled down.

*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Particles are closer together. |  |  |  |  |
| **B** | Particles hit the can with less force. |  |  |  |  |
| **C** | Particles collide with each other less often. |  |  |  |  |
| **D** | The pressure of the air is smaller. |  |  |  |  |

*Physics > Big idea PMA: Matter > Topic PMA4: Particle explanations > Key concept PMA4.2: Pressure*

|  |
| --- |
| **Diagnostic question** |
| **Cold air** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The pressure of a fluid is a measure of how hard its particles are pushing each other apart, and it is proportional to the size of the force exerted by the fluid on a surface. |
| Observable learning outcome: | Explain the effect of temperature change on the pressure of a fixed volume of fluid. |
| Activity type: | Confidence grid |
| Key words: | Pressure, particle |

**What does the research say?**

Following large scale studies of students’ conceptions about gases (n=600, age 11-13) and fluids (n=944, age 14-20) by Séré (1986) and Besson (2004) respectively, both researchers conclude that there is a need for students to systematically reason how the motion of particles cause pressure effects, as a preliminary step in the study of pressure. Ideas about the movement of particles in a fluid can then be used to explain why the force on a surface, F = P x A.

Before using a particle model to explain pressure, it may be necessary to resolve students’ misunderstandings about the motion and distribution of particles in gas. In their study of US college students on a general chemistry course (n=378, age 17-18) Sanger, Vaughn and Binkley (2013) found that although 85% understood how particle speeds increased or decreased with temperature, only 51% predicted the correct distribution of particles in a gas after its temperature had been reduced. Rather than thinking of particles evenly distributed throughout a container, and moving at a slower average speed; nearly half thought that the slowing down of particles in a gas meant that they moved more closely together and clustered in one region of a container.

This question explores students’ understanding of how decreasing the speed of gas particles by cooling affects the pressure of the gas and the distribution of its particles, when volume remains the same.

**Ways to use this activity**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

Statements B, C and D are right.

Statement A is wrong.

**How to respond - what next?**

Particles in the cooler air move less quickly on average than when the air is warmer, so they hit each other and the can less frequently and with less force. The pressure of the air is reduced. Particles In the cooler air still have an average speed in the order of hundreds of metres per second, they easily fill the entire can, and their separation stays the same.

When Sanger et al. (2013) asked the question about particle separation to students (age 17-18, n=378), 28% thought the particles in the cooler gas would cluster in the middle, 12% around the bottom of the can and 9% around the edges. These students appear to be applying the ‘fact’ that gas particles are less spread out in a cooler gas, but this is not true when there is a fixed volume. Those who picture particles close to the bottom of the can perhaps picture the particles as real balls that are affected significantly by gravity.

Sanger et al. (2013) also found that fewer than half of students (age 17-18) understand that pressure decreases when a gas is cooled. 23% thought that pressure would remain the same and 29% that it would increase.

Those who think pressure stays the same or increases may think that pressure is dependent on either the number or the density of gas particles. If they think particles cluster together when they are cooler, some students may also think that this increases their pressure because they are more densely packed.

If students have misunderstandings about explaining the effect of temperature change on the pressure of a fixed volume of fluid, it can be helpful to review their understanding of particles in a gas. Careful questioning can elicit the understanding that particles of a gas always move to fill the whole of a container, which means their average separation does not change with their speed. A useful analogy is to think of the spacing of a fixed number of students walking or running around the whole of a sports hall: separation remains similar when walking, but collisions are less frequent and less painful.

Giving students the task of explaining, in their own words, why pressure decreases as the temperature of gas inside a can goes down, gives them the opportunity to consolidate their understanding.

The following BEST ‘response activities’ could be used in follow-up to this diagnostic question:

* Response activity: Gas pressure
* Response activity: Bottled gas

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG), based on questions in Sanger et al. (2013).

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**References**

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